Rate equations and reaction orders

AQA 7405 · Full A-level

Answer on your own paper. Show your working where needed.

1. Orders and a change in concentration

A reaction follows rate = k[A][B]^2. State the order with respect to A and B and the overall order. Predict the factor by which the rate changes when only [B] doubles at fixed temperature.

2. Compare initial rates

The rows give initial [A], [B] in mol dm^{-3} and rate in mol dm^{-3} s^{-1}.

Run 1: 0.100, 0.100, 2.40 × 10^{-4}. Run 2: 0.200, 0.100, 9.60 × 10^{-4}. Run 3: 0.100, 0.200, 2.40 × 10^{-4}.

Find the rate equation and k with units.

3. A missing concentration

Rate = k[A][B]^2. At a fixed temperature, k = 0.0850 dm^6 mol^{-2} s^{-1}. The rate is 3.40 × 10^{-4} mol dm^{-3} s^{-1} when [A] = 0.250 mol dm^{-3}.

Find [B] to three significant figures.

4. Continuous monitoring

A is the only reactant in the rate equation. A straight concentration-time graph falls from 0.850 mol dm^{-3} at 0 s to 0.550 mol dm^{-3} at 600 s.

Deduce the order with respect to A. Calculate the rate constant and give its units.

5. Interpret a concentration-time experiment

Only A is varied. Tangents to an [A]-time curve give disappearance rates of 2.00 × 10^{-4} at [A] = 0.100, 8.00 × 10^{-4} at [A] = 0.200 and 1.80 × 10^{-3} at [A] = 0.300. Rate is in mol dm^{-3} s^{-1} and concentration in mol dm^{-3}.

Use the data to determine the order in A and calculate k.

6. Relate two species' rates

A → 2B. The tangent to an [A]-time curve at 50.0 s passes through (20.0 s, 0.380 mol dm^{-3}) and (80.0 s, 0.200 mol dm^{-3}).

Find the rate of disappearance of A and the rate of appearance of B at 50.0 s.

7. Two proposed mechanisms

$NO_2 + CO \rightarrow NO + CO_2$ has the experimental rate equation rate = k[NO_2]^2.

Proposal 1: $2NO_2 \rightarrow NO_3 + NO$ (slow), then $NO_3 + CO \rightarrow NO_2 + CO_2$ (fast). Proposal 2: $NO_2 + CO \rightarrow NO + CO_2$ in one elementary step. Decide which proposal fits both pieces of evidence.

8. Work with a reactant in excess

The rate equation is rate = k[A][B]. In one experiment B is in large excess and stays close to 0.400 mol dm^{-3}. Here the data fit rate = k(obs)[A] with k(obs) = 0.0152 s^{-1}.

Calculate k with units. Explain why the simpler fit is possible. Predict k(obs) if B instead stays close to 0.100 mol dm^{-3}.

9. Extra challenge · Two concentrations change together

The rows give initial [A] and [B] in mol dm^{-3} and rate in mol dm^{-3} s^{-1}. Run 1: 0.0800, 0.100, 1.28 × 10^{-4}. Run 2: 0.160, 0.200, 1.024 × 10^{-3}. Run 3: 0.160, 0.100, 5.12 × 10^{-4}.

Deduce the rate equation and k, including units. Predict the initial rate when [A] = 0.120 and [B] = 0.150 mol dm^{-3}. Is an elementary slow first step A + B → products consistent with the data?

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